IEEE CONTROL SYSTEMS SOCIETY TECHNICAL COMMITTEE ON DISCRETE EVENT SYSTEMS

Newsletter..... September 2018

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Contents:

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Editorial

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Welcome to the newsletter of the IEEE Control Systems Technical Committee on Discrete Event Systems!

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Activities

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2.1 Sponsored Activities

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2018 American Control Conference
Milwaukee, Wisconsin, United States, June 27–29, 2018
http://acc2018.a2c2.org/

2018 Conference on Control Technology and Applications
Copenhagen, Denmark, August 21-24, 2018
http://ccta2018.ieeecss.org/

2018 Conference on Decision and Control
Miami Beach, FL, USA, December 17-19, 2018
https://cdc2018.ieeecss.org/

2.2 Technically Co-Sponsored activities

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2018 SICE International Symposium on Control Systems
Tokyo, Japan, March 9-11, 2018
http://iscs2018.sice-ctrl.jp/

The 14th Workshop on Discrete Event Systems
Sorrento Coast, Italy, May 30 - June 1, 2018
http://wodes2018.unisa.it/

30th Chinese Control and Decision Conference (2018 CCDC)
Shenyang, China, June 9-11, 2018

http://www.ccdc.neu.edu.cn/

2018 International Conference on Unmanned Aircraft Systems
Dallas, TX, USA, June 12-15, 2018
http://www.uasconferences.com/

37th Chinese Control Conference (CCC2018)
Wuhan, China, July 25-27, 2018
http://ccc2018.cug.edu.cn/

23rd International Conference on Methods and Models in Automation and Robotics
Międzyzdroje, Poland, August 27-30, 2018
http://mmar.edu.pl/

22nd International Conference on System Theory, Control and Computing
Sinaia, Romania, October 10-12, 2018
http://www.icstcc.ugal.ro/2018/

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Selections of Journal Publications

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Contributed by: Xiang Yin (yinxiang@sjtu.edu.cn)

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SELECTIONS OF THE IEEE TRANSACTIONS ON AUTOMATIC CONTROL
VOLUME: 63 ISSUE: 9
SEPTEMBER 2018

(1) Decentralized Supervisory Control of Networks of Nonlinear Control Systems

Author: Giordano Pola ; Pierdomenico Pepe ; Maria Domenica Di Benedetto

Abstract

In this paper, we propose decentralized control of networks of discrete-time nonlinear control systems, enforcing complex specifications expressed in terms of regular languages, within any desired accuracy. As discussed in the paper, regular languages are useful to model a rather wide variety of complex specifications for control systems. The design of decentralized

controllers is based on formal methods and, in particular, on the use of discrete abstractions. Efficient synthesis of such controllers is derived by resorting to on-the-fly algorithmic techniques that also allow the use of parallel computing architectures. Advantages and disadvantages of the decentralized approach over a centralized one, also in terms of computational complexity, are discussed. An illustrative example is presented, which shows the applicability and effectiveness of the results proposed.

Full-text available at: https://ieeexplore.ieee.org/document/8115304/

(2) Passivity-Based Design for Event-Triggered Networked Control Systems

Author: Arash Rahnama ; Meng Xia ; Panos J. Antsaklis

Abstract

In this paper, we introduce a passivity-based design framework for event-triggered networked control systems. We consider the effects of network-induced time delays, signal quantization, and data loss in communication links between the plant and controller and show L2 -stability and robustness for the control design. We introduce simple asynchronous triggering conditions that do not rely on the exact knowledge of the systems' dynamics and are located on both sides of the communication network. This leads to a great decrease in the communication rate between systems. Additionally, we show lower bounds on interevent time intervals for the triggering conditions and characterize the design's robustness against external disturbances. We illustrate the relationship among stability, robustness, and passivity levels of the plant and controller. Moreover, we analyze our design's robustness against packet dropouts. Finally, we calculate the passivity levels for the entire event-triggered networked control system. This is beneficial in design of compositional networked control systems. Our results are design-oriented. By following our proposed framework, the designer can characterize clear tradeoffs among passivity levels, design parameters, time delays, effects of signal quantization and triggering conditions, stability, robustness, and performance, and make design decisions accordingly.

Full-text available at: https://ieeexplore.ieee.org/document/8113521/

(3) Infinite Time Horizon Maximum Causal Entropy Inverse Reinforcement Learning

Author: Zhengyuan Zhou ; Michael Bloem ; Nicholas Bambos

Abstract

Inverse reinforcement learning (IRL) attempts to use demonstrations of “expert” decision making in a Markov decision process to infer a corresponding policy that shares the “structured,

purposeful” qualities of the expert's actions. In this paper, we extend the maximum causal entropy framework, a notable paradigm in IRL, to the infinite time horizon setting. We consider two formulations (maximum discounted causal entropy and maximum average causal entropy) appropriate for the infinite horizon case and show that both result in optimization programs that can be reformulated as convex optimization problems; thus, admitting efficient computation. We then develop a gradient-based algorithm for the maximum discounted causal entropy formulation that enjoys the desired feature of being model agnostic, a property that is absent in many previous IRL algorithms. We propose the stationary soft Bellman policy, a key building block in the gradient-based algorithm, and study its properties in depth, which not only lead to theoretical insight into its analytical properties, but also help motivate a large toolkit of methods for implementing the gradient-based algorithm. Finally, we select three algorithms of this type and apply them to two problem instances involving demonstration data from a simple controlled queuing network model inspired by problems in air traffic management.

Full-text available at: https://ieeexplore.ieee.org/document/8115277/

(4) Approximate Value Iteration for Risk-Aware Markov Decision Processes

Author: Pengqian Yu ; William B. Haskell ; Huan Xu

Abstract

We consider large-scale Markov decision processes (MDPs) with a time-consistent risk measure of variability in cost under the risk-aware MDP paradigm. Previous studies showed that risk-aware MDPs, based on a minimax approach to handling risk, can be solved using dynamic programming for small- to medium-sized problems. However, due to the “curse of dimensionality,” MDPs that model real-life problems are typically prohibitively large for such approaches. In this technical note, we employ an approximate dynamic programming approach and develop a family of simulation-based algorithms to approximately solve large-scale risk-aware MDPs with time-consistent risk measures. In parallel, we develop a unified convergence analysis technique to derive sample complexity bounds for this new family of algorithms.

Full-text available at: https://ieeexplore.ieee.org/document/8247278/

(5) Stochastic Optimization in a Cumulative Prospect Theory Framework

Author: Cheng Jie ; Prashanth L. A. ; Michael Fu ; Steve Marcus ; Csaba Szepesvári

Abstract

Cumulative prospect theory (CPT) is a popular approach for modeling human preferences. It is based on probabilistic distortions and generalizes the expected utility theory. We bring the CPT

to a stochastic optimization framework and propose algorithms for both estimation and optimization of CPT-value objectives. We propose an empirical distribution function-based scheme to estimate the CPT value, and then, use this scheme in the inner loop of a CPT-value optimization procedure. We propose both gradient based as well as gradient-free CPT-value optimization algorithms that are based on two well-known simulation optimization ideas: simultaneous perturbation stochastic approximation and model-based parameter search, respectively. We provide theoretical convergence guarantees for all the proposed algorithms and also illustrate the potential of CPT-based criteria in a traffic signal control application.

Full-text available at: https://ieeexplore.ieee.org/document/8329994/

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SELECTIONS OF AUTOMATICA
VOLUME: 95
SEPTEMBER 2018

(1) What information really matters in supervisor reduction?

Author: Rong Su ; W. Murray Wonham

Abstract

To make a supervisor comprehensible to a designer has been a long-standing goal in the supervisory control community. One strategy is to reduce the size of a supervisor to generate a control equivalent version, whose size is optimistically much smaller than the original one so that a user or control designer can easily check whether a designed controller fulfils its objectives and requirements. After the first journal paper on this topic appeared in 1986 by Vaz and Wonham, which relied on the concept of control covers, Su and Wonham proposed in 2004 to use control congruences to ensure computational viability. This work was later adopted in supervisor localization theory, which aims for a control equivalent distributed implementation of a given centralized supervisor. Despite these publications some fundamental questions, which might have been addressed in the first place, have not yet been answered, namely what information is critical to ensure control equivalence, what information is responsible for size reduction, and whether partial observation makes the problem essentially different. In this paper we address these questions by showing that there exists a unified supervisor reduction theory, which is applicable to all feasible supervisors regardless of whether they are under full observation or partial observation. Our theory proposes a preorder (called leanness) over all control equivalent feasible supervisors based on their enabling, disabling and marking information such that, if a supervisor is leaner than another supervisor , then the size of the minimal control cover defined over the state set of is no bigger than that of .

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818302966

(2) Multiple stopping time POMDPs: Structural results & application in interactive advertising on social media

Author: Vikram Krishnamurthy; Anup Aprem; Sujay Bhatt

Abstract

This paper considers a multiple stopping time problem for a Markov chain observed in noise, where a decision maker chooses at most stopping times to maximize a cumulative objective. We formulate the problem as a Partially Observed Markov Decision Process (POMDP) and derive structural results for the optimal multiple stopping policy. The main results are as follows: (i) The optimal multiple stopping policy is shown to be characterized by threshold curves , for , in the unit simplex of Bayesian Posteriors. (ii) The stopping sets (defined by the threshold curves) are shown to exhibit the following nested structure . (iii) The optimal cumulative reward is shown to be monotone with respect to the copositive ordering of the transition matrix. (iv) A stochastic gradient algorithm is provided for estimating linear threshold policies by exploiting the structural results. These linear threshold policies approximate the threshold curves , and share the monotone structure of the optimal multiple stopping policy. (v) Application of the multiple stopping framework to interactively schedule advertisements in live online social media. It is shown that advertisement scheduling using multiple stopping performs significantly better than currently used methods.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818303054

(3) Finite-horizon LQR controller for partially-observed Boolean dynamical systems

Author: MahdiImani Ulisses; M.Braga-Neto

Abstract

This paper proposes an approach for finite-horizon control of partially-observed Boolean dynamical systems (POBDS) with uncertain continuous control input and infinite observation space. To cope with the partial observability of states, the proposed method first maps the POBDS to an unnormalized belief space. The nonlinear dynamics in this continuous belief space are linearized over a nominal trajectory. Then, the optimal feedback controller is derived, based on the well-known linear quadratic regulator (LQR), to push the system to follow the nominal trajectory. This nominal trajectory is computed in a planning stage before starting execution, and updated efficiently during execution, whenever the system is found to deviate from the nominal trajectory. We prove that, under mild regularization conditions, the proposed controller approaches the cost of the nominal trajectory as the linearization error approaches

zero. The performance of the proposed controller is demonstrated by numerical experiments with a Melanoma gene regulatory network observed through noisy gene expression measurements.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S000510981830270X

(4) Event-triggered control for robust set stabilization of logical control networks

Author: Yalu Li ; Haitao Lia ; Weiwei Sun

Abstract

This paper addresses the robust set stabilization problem of -valued logical control networks (KVLCNs) via the algebraic state space representation approach, and proposes an event-triggered control scheme. Based on the algebraic form of KVLCNs, a necessary and sufficient condition is presented for the robust set stabilization of KVLCNs via time-variant state feedback control. Moreover, the event-triggered control design problem is formulated, and a sufficient condition is presented to design state feedback event-triggered controllers for the robust set stabilization of KVLCNs.

Full-text available at: https://www.sciencedirect.com/science/article/pii/S0005109818303224

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SELECTIONS OF DISCRETE EVENT DYNAMIC SYSTEMS: THEORY AND APPLICATIONS
VOLUME: 28 ISSUE: 3
SEPTEMBER 2018

(1) Simulations and bisimulations for analysis of stability with respect to inputs of hybrid systems

Author: Pavithra Prabhakar, Jun Liu, Richard M. Murray

Abstract

Simulation and bisimulation relations define pre-orders on processes which serve as the basis for approximation based verification techniques, and have been extended towards the design of continuous and hybrid systems with complex logic specifications. We study pre-orders between hybrid systems which preserve stability properties with respect to input. We show that these properties are not bisimulation invariant, and hence propose stronger notions which strengthen simulation and bisimulation relations with uniform continuity constraints. We show

that uniform continuity is necessary on the relations corresponding to both the state-space and the input-space, and continuity itself does not suffice. Finally, we demonstrate the satisfiability of our definitions by casting the well-known Lyapunov function based techniques for stability analysis as constructing a simple one-dimensional system which is stable and uniformly continuously simulates the original system.

Full-text available at: https://link.springer.com/article/10.1007/s10626-017-0262-9

(2) A hierarchical consistency framework for real-time supervisory control

Author: Quang Ha Ngo, Kiam Tian Seow

Abstract

The control framework of hierarchical consistency of timed discrete-event systems (TDES's) is investigated in a standard two-level hierarchy. Real-time concepts and the associated theoretical results supporting consistent TDES hierarchies are developed. Where the given low-level system model of the hierarchy possesses time fidelity, a consistency version that assures time fidelity of the high-level system model is also developed. Importantly, this version furnishes a sound real-time high-level specification design foundation for hierarchical control. An example illustrates the new time-fidelity control foundation. Given that in general, a given two-level TDES hierarchy is not hierarchically consistent between the levels, the structural existence and synthesis of the sufficiency structure for hierarchical consistency is investigated. Both the timed versions of hierarchical consistency - without and with output-time fidelity guarantee - are successively treated. The abstraction or output-system refinement procedures for the version without output-time fidelity guarantee are first developed for a class of TDES hierarchies under mild output-system design restrictions. The abstraction methods for the version with output-time fidelity are then developed for a subclass 'linearly' structured under further output-system design restrictions. A detailed example explains and illustrates the use of an overarching method developed.

Full-text available at: https://link.springer.com/article/10.1007/s10626-018-0267-z

(3) On controlling prioritized discrete event systems with real-time constraints

Author: Lei Miao

Abstract

We study a class of prioritized Discrete Event Systems (DESs) that involve the control of resources allocated to tasks under real-time constraints. Our work is motivated by applications in communication systems, computing systems, and manufacturing systems where the

objective is to minimize energy consumption while guaranteeing that task deadlines are always met. In the off-line setting, we discover several structural properties of the optimal sample path of such DESs. Using the structural properties, we also propose a greedy algorithm which is shown numerically near optimal. For on-line control, we design a Receding Horizon (RH) controller. Using worst-case estimation, the RH control is able to guarantee feasibility (when the off-line problem is feasible) and achieve good performance.

Full-text available at: https://link.springer.com/article/10.1007/s10626-018-0269-x

(4) Detectability of networked discrete event systems

Author: Yazeed Sasi, Feng Lin

Abstract

Detectability of discrete event systems, defined as the ability to determine the current and subsequent states, is very important in diagnosis, control, and many other applications. So far only detectability of non-networked discrete event systems has been defined and investigated. Non-networked discrete event systems assume that all the communications are reliable and instantaneous without any delays or losses. This assumption is often violated in networked systems. In this paper, we study detectability for networked discrete event systems. We investigate the impact of communication delays and losses on detectability. We define two classes of detectabilities: network detectability for determining the state of a networked discrete event systems and network D-detectability for distinguishing certain pairs of states of the systems. Necessary and sufficient conditions for network detectability and network D-detectability are derived. Methods to check network detectability and network D-detectability are also developed. Examples are given to illustrate the results.

Full-text available at: https://link.springer.com/article/10.1007/s10626-018-0269-x

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SELECTIONS OF THE IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY
VOLUME: 26 ISSUE: 5
SEPTEMBER 2018

(1) Formal Methods for Stability Analysis of Networked Control Systems With IEEE 802.15.4 Protocol

Author: Bo Wu ; Michael D. Lemmon ; Hai Lin

Abstract

Wireless networked control systems (WNCSs) with control loops closed over a wireless network are prevailing these days. However, due to uncertainties such as random accessing delays and possible packet drops, the stability analysis for a WNCS is a challenging task. Most previous studies on the communication network analysis either relied on Monte Carlo simulation or followed the multistate Markov chain framework. In this paper, our main contribution is to propose a formal method-based stability analysis in which the communication system is modeled as a probabilistic timed automaton. The underlying communication protocol is analyzed through probabilistic model checking. In particular, the stability condition of the WNCS is expressed in the probabilistic temporal logic formula as the quality of service requirement, which can be checked, and the satisfaction of the specification is equivalent to the stability guarantee of the WNCS. We then study the impact of different media access control (MAC) parameters on the satisfaction of the specification. Furthermore, if the specification is not satisfied initially, we propose a systematic way to tune the MAC parameters or redesign the controller so that the specification can be met. This paper presents an attempt and a new angle to the communication and control system codesign problem.

Full-text available at: https://ieeexplore.ieee.org/document/7993094/

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SELECTIONS OF THE IEEE TRANSACTIONS ON SYSTEMS, MAN AND CYBERNETICS: SYSTEMS
VOLUME: 48 ISSUE: 9
SEPTEMBER 2018

(1) Discrete-Event Simulation and Integer Linear Programming for Constraint-Aware Resource Scheduling

Author: Seung Yeob Shin ; Yuriy Brun ; Hari Balasubramanian ; Philip L. Henneman ; Leon J. Osterweil

Abstract

This paper presents a method for scheduling resources in complex systems that integrate humans with diverse hardware and software components, and for studying the impact of resource schedules on system characteristics. The method uses discrete-event simulation and integer linear programming, and relies on detailed models of the system's processes, specifications of the capabilities of the system's resources, and constraints on the operations of the system and its resources. As a case study, we examine processes involved in the

operation of a hospital emergency department, studying the impact staffing policies have on such key quality measures as patient length of stay (LoS), number of handoffs, staff utilization levels, and cost. Our results suggest that physician and nurse utilization levels for clinical tasks of 70% result in a good balance between LoS and cost. Allowing shift lengths to vary and shifts to overlap increases scheduling flexibility. Clinical experts provided face validation of our results. Our approach improves on the state of the art by enabling using detailed resource and constraint specifications effectively to support analysis and decision making about complex processes in domains that currently rely largely on trial and error and other ad hoc methods.

Full-text available at: https://ieeexplore.ieee.org/document/7887737/

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